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St. Lawrence Canals and Gradual Diminution of the Discharge of the River St. Lawrence.

OF THE ST. LAWRENCE CANALS.

There appeared lately in the newspapers a letter addressed to the Editor of the *Montreal Herald*, signed "J. B. Mills", in reference to the Williamsburgh Canals, on the river St. Lawrence, of which it appears that complaints had been made, that the bottom levels are not laid sufficiently low, to afford a proper depth of water, and charging a blunder of engineering in their construction. Mr. Mills in this letter says, "as "the remarks imply a charge of blunder in engineering—and, as I "have acted a most prominent part in construction of said canals, it "is no doubt proper for me to notice said remarks in the way of "reply, and I do so, not as replying to the exaggerations of newspaper "paragraphs; but in the face of the country, and in the view of the "relation which I have had the honor of holding to the Department "of Public Works of Canada, to state the circumstances and facts "which bear upon the subject of said remarks. But to the point— "what is this blunder?

"In substance it is said that the grades, or the levels of the bottom "of those canals are not laid low enough with respect to the St. Law- "rence."

"I acknowledge that in the year 1848, the water of the St. Law- "rence—therefore, the water of these canals, has been lower, than "would have been expected, from the information in my possession "at the time the levels were established, but I conclude that it is in "the future experience of the country to determine whether or not "an error has been made, to what circumstance the error is justly "chargeable."

By this Mr. Mills seems not to admit the country's experience of 1848—although by him acknowledged that the levels of those

canals are not sufficiently low, according to the low state of the St. Lawrence of that year, and of which he says, it was unexpected,—and demands upon whom this error is chargeable, or to what circumstance. It certainly appears that the error of those levels not being sufficiently low for 1848, in the present view can only be chargeable to the "*information in possession at the time, the levels were established*," for had this information been better, or probably a better use made of it, than apparently has been done, the Engineer would have placed those levels lower.

Next he says, "the levels of those canals were established in "spring, 1843. In determining the matter, the Engineer had in possession the last available information of the variation of the St. Lawrence during an interval of more than twenty years next preceding "1843.—Query—Had he not data of an interval long enough, to "determine the levels of these then proposed canals."

"Can there be more than one answer to the question, and that the "interval is quite long enough. If so then the charge of 'blundering' is unjust—as from the information referred to, the levels as established are right, with reference to the intentions of the Government."

Here again Mr. Mills makes the "blunder" rest wholly upon the best available information and time of twenty years previous to 1843! but he does not state from what source, or upon what observation this information was, or how obtained;—whether from a regular register of the levels for each of those twenty years, or only this collected from the ordinary observations of those navigating the river, or from those residing that time on its banks. But admitting the first—would this register warrant the probability to have answered for establishing a canal for the next twenty years at the minimum level of this time—even if such canal should be wanted no longer—and farther allowing this register had been extended to forty years, and not varying from the other, would a considerate and qualified Engineer think himself bound to establish his work on the minimum level of this period, while either period might be considered "*sufficiently available information*" in the hands of such Engineer.—Certainly not.—an experienced Engineer from such information would have put his level below the minimum

of those periods: for it would not do to split hairs with the St. Lawrence.

Mr. Mills does not inform us with regard to the relation of his canal levels and the levels of those twenty years, that is, whether those levels were put higher or lower than the minimum level! but he says "the levels of those canals as established are *right* with res- "pect to the waters of the St. Lawrence and the *intentions of the* "*Government*, for this entire interval of time, which interval, *indepen-* "*dently* ought to be considered long enough, to indicate the levels that "should have been adopted."

It would now appear that the "blunder" in establishing those canals is more chargeable to the St. Lawrence itself, which has done very wrong in becoming lower in 1848 than in the preceding twenty years, (if this was the fact.) And still more, after the levels of those canals were established *right* by the Engineer, both according to *itself*, and the *Government intentions*—especially as a presumed adequate time of twenty years, had been taken as sufficient, by which all its variations of level ought to have been shown, and moreover ought not to have been departed from thereafter.

In 1834 the writer of this was employed by the Commissioners of th. then proposed Cornwall Canal, to inspect and report upon its route as laid off by Messrs Wright and Mills, in which Report it is stated regarding the levels to be made in establishing this navigation, 'I think it adviseable to construct all the locks to twelve feet water, 'which would be a better proportional depth for this than ten feet as 'has been proposed for the Inland Canal—for although only ten feet 'channel is first obtained on the river route, the additional two feet 'may be progressively added as may be required, and the more easily 'as a dredging machine, which I advised, is now obtained for the 'Lower Province, and is the most effective in use,'* and had this advice been adopted the bottom levels of the St. Lawrence Canals all through would have now been found two feet lower than those by Mr. Mills. Farther had the Cornwall Canal been constructed on the route laid

* See printed Report No. 7, of the Commissioners appointed to superintend the improvement of the Navigation of the St. Lawrence.

out by that Report—the navigation of this portion of the river St. Lawrence would have been much better adapted to steamboats than the present canal, and would not have cost much more than half the expence, which has been laid out upon it.

Mr. Mills next makes the supposition of a forty years report showing the river to have been much lower than in the last twenty years at the time of establishing those canals, and that this Report should be set aside, presuming it was only derived from such and such shoal or rocks being bare; although exhibiting a much lower level than his twenty years report; but which report cannot be depended on; because he says rocks and shoals are frequently moved and moveable by ice. It is, however, very evident that had he established the canals at this lower level of forty years supposed report, a serious blunder might by his own account have been avoided. To this he adds, "is the En- "gineer to throw away said information, (of 20 years) in possession, "and seek after *this some level or other* whereupon to establish his "levels? I think not and for reasons—First, that that low level (of "40 years) is absolutely unknown and cannot be ascertained.— "Secondly, whether low or not, there is no physical law governing the "St. Lawrence, that determines that river will be so low again."

As before, let it be admitted, that the lowest levels of the St. Lawrence had been correctly taken, for each of the twenty years, preceding the establishing of the levels of those Canals by them, or by the lowest or minimum level of that period. I would ask by what condition or principle this river should not be found to vary from this in the next twenty years? or to what limit and time would those observations in this period warrant the extent of its future variations of level? and how has it happened that it should make such an anomaly in 1848, and to have been so unexpected--or is it the fact that the state of the river in 1848 was one of great probability, from the very information of twenty years preceding the time Mr. Mills had obtained his best information, (if such information was correct) and which state might not be the least in opposition to its ordinary ruling causes?

It appears farther by Mr. Mills's opinion "there is no physical law "governing the St. Lawrence that determines that river will be so

low again." This, if true, accounts for its unexpected low state in 1848. The St. Lawrence then must have a free will of its own, by which alone it rises or falls, and consequently may choose any particular year to fall unusually low, and who knows but for the purpose of direct opposition to the Engineer's best information, and to the Canadian government's intentions! but I cannot see as Mr. Mills seems to see, that it may not be so low again by the same will, for this would presume upon some physical law governing that will hereafter, which had not been before in action, or that the Government with its Engineer had made a better and a mutual understanding for the future state of this river! But rejecting this independent will of the St. Lawrence, let us inquire if there are any physical laws whatever which may act, or always have acted upon this river, and affect its rise or fall, and even account for its seeming anomaly in 1848. This enquiry at least may be somewhat interesting for the future, and even may be useful information for the establishment of works upon it, in the hands of qualified and competent Engineers.

OF THE GRADUAL DIMINUTION OF THE DISCHARGE OF THE RIVER ST. LAWRENCE.

If we turn our eyes upon a Map of the Continent of North America, we see the River St. Lawrence with its sources the Great Lakes, namely, Ontario, Erie, Huron, Michigan and Superior, and also that portion of land shown by the rivers and streams draining into them.—Now if we draw, or trace a boundary line around the heads of the streams, not lower than the confluence of the River Ottawa with the St. Lawrence we shall find the surface within this boundary which is covered with water, or those Lakes, is at least equal if not greater than that which drains into them, a circumstance peculiar to the sources of the River St. Lawrence, and to no other known river on the Globe. Those lakes form great and collecting reservoirs, from which alone the River St. Lawrence has its whole supply of water, and upon which the heaviest and most constant rains can only raise their surfaces,

in a very small degree, and they become, a regulating power of the quantity of water issuing from Lake Ontario, or the discharge by the St. Lawrence. Along with this we know that the average fall of rain is always very nearly equal over the same county, or district, and consequently the annual mean differences of rise or fall of those surfaces, will be confined within very narrow limits, or be almost insensible, and also the annual mean discharges of the St. Lawrence be equally little varied, or be nearly constant, that is supposing any diminishing causes suspended, or that these discharges shall be the full effect of the rains and drainages. This is one physical law governing the River St. Lawrence.

Another operating influence upon the sources of this river, is the evaporation over the same extent of surface, as that of the rains, and which we had supposed suspended in the above law, but which acts considerably in diminishing the rain supply, or that which would be given without evaporation by the rains. In fact, the rains without evaporation would regulate the full supply at nearly an equal or a constant quantity annually, this evaporation would also regulate the supply, only it would be of a much less constant quantity.

Also as the average temperature annually of the same parallel of latitude is found to be nearly equable, the diminished supply by evaporation, would be only affected proportionally, and be annually less, or more, in a very small degree, and thereby leave the annual difference, or supply always nearly equal, and consequently the discharge of the river of little or no annual difference. This is another and second physical law governng the St. Lawrence.

Now seeing that there are two distinct and special operating powers or physical laws relative to the St. Lawrence, the one neutralizing to a certain and constant extent the other, and thereby limiting within moderate bounds the discharge of this river, which gives it that peculiar character of being confined within the difference of two feet in its annual rise and fall, our next enquiry is, how the St. Lawrence may be subject to any anomaly from this difference, or that this would become very disproportionate in certain years to that of others, and which anomaly might lead us to suppose, that some foreign cause not usually

acting upon this river, had been produced to diminish extraordinarily, or increase its supply. Such, as is presumed, was the first that had taken place in 1848,—contrary (if true) to previous twenty years observations of its levels, according to the engineers of the Canadian Board of Works.

It has been stated above, that the average quantity of rain is annually nearly equal, and also the same, of the annual mean temperature; but the truth is, neither of these is ever exactly equal, as each is somewhat greater or less in one year than another, and their annual differences can only be ascertained by proper registers being kept of them for each year, in which their proper measures have been taken; but we know that if the rain average of one year be increased over another, the mean temperature of same year will in all probability be diminished; so in this case the differences in lesser evaporation would increase the supply, to add to the increase of rain; the supply always being the difference of their respective effects, or the difference of the supply of the supplying power, and the evaporative power. On the opposite, if the rain average of one year is diminished, the mean evaporative power will be increased, and consequently the supply of the Lakes would be diminished; for in dry seasons the mean temperature is usually higher. Hence we see as the variations of effect, of those two different powers which make supply, that this supply will at the same time be also variable, thereby producing variations of the lakes surfaces, in a lesser or greater degree above or below the mean height of the time observed, or period of annual observations. And thus were these variations equally alternating and periodically taking place, the hydraulic mean height of these variations of the lakes surface, would be in a plane similar to the invariable plane of the Heavens, made by the oscillations of the planetary orbits, and be for ever stationary, while this mean would give a discharge equal to the sum of the discharges of the varying heights of the same time, and consequently the annual discharge, of that or of other periods of the St. Lawrence, would also be invariable; but without a proper register being kept of the rises and falls of the surface of Lake Ontario, and other elements of this physico-mathematical problem, it cannot be ascertained directly at the present time.—That

is whether this mean height to any given period is constant, or returns periodically, to be in the same invariable plane, or whether it is altering from this in only one direction in relation to a given height. However, it is obvious from the above, that the supply is the effect of these two powers, or laws, from their opposite tendency, acting in the same time, and the variations of this can only oscillate within narrow limits, with some small and gradual alteration from such plane, which effect may be considered to be the special physical law governing the discharge of the St. Lawrence issuing from Lake Ontario.

To follow our inquiry in the absence of registered observations, we shall now call in common observation of cause and effect within our daily and ordinary experience, which may lead us to conclude at least, upon some, or the most probable results, to be expected from the operating powers now directly producing the supply of water on those lakes,—also regarding its change or variations in quantity, from other or indirect physical influences to which these powers may become, or are now subject.

We have seen the effect of the two powers is this supply arising from their opposite tendency,—the one filling by the rains and the other diminishing by evaporation, and it is evident that in the event of the evaporative power being the greatest, that the supply by the other would come to be successively reduced ; so as to afford no discharge, and ultimately render those lakes totally dry ;—On the other hand were the supply by the rains greater than the evaporative power can raise, the result would be a discharge, and if both equal, any discharge existing at the time of their becoming so, would be reduced to the bed of the outlet, at which level the surface of the lake would afterwards remain stationary with no discharge ; and in every case of discharge, the quantity discharged, together with that raised by the evaporation over all the lakes, will always be equal to the whole or full supply made by the rains in the same annual time: but if the supply was only increased, this would not alter the last equality, but would raise the altitude of the lakes surface, and consequently its mean hydraulic height,* always sup-

* The mean hydraulic height is that which would uniformly give the discharge equal to the discharge made by variations of level in the same time.

posing there are no other sources of supply than by the rains and drainages.

We believe it will be admitted that there has been no successive increasing rise of the lakes forming the supply of the St. Lawrence, or rather Lake Ontario to which we may only now refer, as being the collecting reservoir from which the St. Lawrence directly issues; for a successive increasing rise of this lake, would at least indicate a successive greater annual fall of rain, or a continued annual decrease of the mean temperature, which has yet not been observed; as little have ocular marks upon its shores shown, that this is taking place, and we cannot in the present inquiry recognize any other cause that would make a permanent rising of this lake, and consequently we cannot suppose that its hydraulic mean height, has ever risen increasingly from a lower to a higher level;—Hence the discharge of the St. Lawrence could not have gradually been on the increase.

Respecting the only possible states of this lake as stated above, that is, if the hydraulic mean height is permanent; or if this mean height is on an invariable plane of the lakes surface, or if this plane varies from a higher to a lower level, we have shown that the first can only be accurately known, by having a register of its height, for a series of years, which would show if its mean annual oscillations would result in a constant mean height, or give this mean, at a varying lower level. In the absence of this register we can only refer to the probable results which might arise from the laws we have already found established, and that govern the supply, combined with any known alterations these may be subject to, caused from local or other influences not yet introduced; for regarding the latter state, or increasing depression of the mean height, without such influences, there are the same opposite objections as for an increasing rise, which is, that this depression would indicate a successive decreasing annual fall of rain, and increasing mean temperature, which I believe is yet equally hitherto unobserved as of the contrary, or that the evaporative power and discharge together, had become greater than the full supplying power by the rains.

In the case of the latter state being supposed there consequently must be another, and additional source of supply to make this state possible.—Then let us first examine how any such additional supply would be derived, and be at the same time consistent with, or co-exist with the known causes of that by the rains.

If we take an ocular survey of those lakes we shall certainly find many evident marks, showing that their waters have covered a greater extent of surface, and from which now they have receded, namely, marshes along their shores which have been formerly under water, and have every indication of having been the ancient bottom, the same also may be observed along the St. Lawrence, for which we have not need to refer to any general deluge; but only to the simple and ordinary operations of nature, which have left the same marks on the shores of every body of water detached from the Ocean, that is found both above and below its level—as those above the level of the ocean may have been brought to lower levels by a gradual deepening of their outlets by the continued action, or attrition of their issuing currents, although by slow or almost imperceptible degrees; while others might be from very remote eruptive causes, which would bring the lakes' surface to a lower level, by making a wider or deeper opening in the outlet. The first, however, would cause no increase or decrease of the discharge, but the other would instantly increase this, by drawing off a portion of the ancient waters that were previously below the level of their former outlet, to the level of the new one so made, but which would be speedily exhausted, and the lake would be reduced to its first discharge.—Hence in both cases the equality would again be that of the discharge, together with the quantity raised by evaporation, to the full supply by the rains.—Again those lakes found below the level of the Ocean must have been so reduced in their levels, by the evaporative power becoming greater than the supply by the rains, which is allowed to be the effect on the Caspian and Dead Seas; therefore from all the observations made upon the sources of the St. Lawrence which we have yet introduced, we can only come at the conclusion at the present time, that the discharge of this river is alone the production of the rains, and would remain with its mean height stationary, provided no other addi-

tional source should be found, or foreign cause, either to enlarge or lessen it. Let us examine if there may be any such.

If we look again upon the Map of North America, we shall see that there are few rivers of any great magnitude, that fall into the Lakes Superior, Michigan, Huron, Erie and Ontario, and those that do, are short in their courses, and for the greater part through flat, at least not hilly country, and the whole drainage by them, would appear to be small, and affording a very limited supply of water, comparatively to the great collecting and evaporating surfaces, presented by those lakes; for if we begin at Kingston and survey upward throughout the whole of Upper Canada, and thence along the northern shores of Lake Huron and Superior, the rain drainage of the whole of this looks very small, by its extending not far from the shores; as that on the first, there is no river of any magnitude or length of course as a feeder, which would add sensibly little to the volume of water, and great surfaces of those vast inland reservoirs. Also in returning around, upon their southern shores, the same drainage appears equally limited, for the drainage of the Mississipi, Illinois, Wabash, Miami, and Ohio Rivers draw all nearly off from the shores of Superior, Michigan and Erie, and with some exception of that which drains from New York State into Lake Ontario by Genesee, with a few other rivers of no great extent. On the other side the tributaries of the Ottawa, and those that empty into Hudson Bay, draw off their waters very near to Lakes Huron and Superior, thereby leaving only a narrow belt of land drainage, surrounding those great lakes, and from which they can apparently have no other supply of water, but the rain which falls on their own surfaces.

In taking the above view, it may appear that the drainage if measured by the apparent magnitudes of the rivers discharging into those lakes, together with the rains on their surfaces, is much smaller than that discharged by the St. Lawrence; but as we have no correct means at the present time of ascertaining this, we can only add a conjecture of there being an additional supply to that by the rains.—There seems to be some probability of this supply having a real source as has been impressed upon the mind of the writer for some years past, by the fact,

that by some measurements which have been made, Lake Superior is found to be six hundred and twenty-seven feet above the level of the sea, and its bed three hundred and thirty-six feet below that level, together giving a total depth of nine hundred and sixty-three feet, thus forming an immense concavity in the country, which if connected with the ocean would instantly be filled to the depth of three hundred and thirty-six feet of salt water. Now let us suppose that this concavity was instantly emptied of its present contents, and all the streams issuing into it at the same time stopt above its present surface level; here then we would have an immense empty concavity with its bottom much below the level of the Ocean, and much more below all the standing and living waters of the surrounding continent for hundreds of miles distant.—Also as this concavity may have been formed from a very remote eruptive cause, its geological structure will be in all probability, wholly declining or dipping towards its centre, through which the filtration of water from a considerable distance may from all sides collect into it, and thus form a supply to this lake over and above that by the rains, and in all probability be an annual constant quantity, to discharge by the St. Lawrence, but would maintain the mean height of Lake Ontario at a higher level than by the latter only.

However, the above supposed additional supply to the rains may be, or not be, we have not yet found any cause, which would progressively raise the mean height of the lakes, or annually increase the supply, and therefore our last enquiry is to find if there are any to successively depress this height, or by which the supply may be annually lessened.

In all countries covered with forests, the first step of occupation is to clear them off for the cultivation of the land, which is generally done along the borders of the rivers, thus exposing the surfaces of both land and water on a greater extent to the direct rays of the sun and to the sweeping winds; which exposure consequently will greatly increase the evaporation over those surfaces, many times more, than when under entire shade, especially to the latter; also the cultivation of the land by turning up and opening of the soil, gives it an additional absorbent

power to hold the rains for vegetation and for exhalation, which before would run off upon a hard or saturated surface. It is therefore evident that the clearing and cultivation of the country must in a very great degree increase the evaporation, and consequently diminish or dry up the numerous small streams and rills which contributed to fill the larger channels and rivers, hence in the event of these changes being extended over a great surface of country, the rivers of that country must have been also considerably diminished, and progressively as those clearing operations had advanced. If we now apply these effects to the belt of land surface, draining into those great lakes, it is certain the supply of water will be diminished in proportion to the new cleared surface so exposed to greater evaporation, and consequently the discharges of the St. Lawrence lessened. Such diminution of this might not be remarkable in one age, and therefore could not be almost ocularly observed by those most familiar with it, until made somewhat conspicuous by another coinciding cause, producing a like effect, such as one or two successive dry seasons, by which the level might then become comparable to some recollected mark, but without suspecting that the difference had been made chiefly progressively. From those diminishing causes it is easy to account for the low state of the St. Lawrence in 1848.

At the commencement of clearing off the forests, this work would proceed very slowly: but as the population increased this would go on more rapidly, especially in a country continually supplied by adult population, as that draining into the Lakes has been; and consequently the diminution of the St. Lawrence from an increased evaporation within a few years back must have greatly increased, more than in the same previous period, as any diminution from this cause must have only commenced after the first settlement upon it, which may not exceed fifty or sixty years back and for some time this diminution would be insensible.

The above evident causes of diminution may have been added to, by the average fall of rain also diminishing, from the same clearing of the forests; for it is allowed that rain is the production of changes of temperature of the atmosphere, or from the conterminous sur-

faces of moist volumes of the atmosphere of different temperatures intermingling, by which a portion of that moisture is deposited in the form of rain ; then such volumes of different temperatures are much more likely to be produced from standing forests and wooded swamps, than from a country entirely open and affording a free circulation of temperature in its atmosphere,—hence the annual average of rain may be also decreased.

As stated above, a country covered with forest,—as a great portion of North America is, the clearing of this is the first and absolutely necessary operation in agriculture, and the only general improvement for a long time to come, at least until the dry lands are cleared and used for cultivation, and leaving the moist and marshy land untouched for direct farming purposes.—Again when the first are occupied by a dense population, draining the other will follow as the next improvement, this being in all countries only practised when the dry land becomes scarce, and much increased in value, or in very moist climates in which it is required on the dry lands to prevent them from being chilled by overmoisture.—Also whenever draining becomes a general practice and use in a country, it is obvious that it will be most effective in accelerating the surface waters to the main streams and rivers, and often so rapidily during heavy and continued rains, as to cause sometimes calamitous inundations in their courses.—Consequently a general system of agricultural draining, around those great lakes, would be a considerable means of adding to the supply of water, which first would certainly be much diminished, by the increased evaporation caused by the first clearing of the land. But such a system cannot be expected to be in operation to have such general effect for ages yet to come, while the clearing of the forest on the shores of Lakes Ontario, Erie and Huron will proceed every year with a geometrically progressive pace.—Hence every succeeding year will the evaporative power be many times increased over those clearances, and the supply to the lakes diminished, which is now become very visible in 1848, and which will continue as a certain result of the opposite tendency of the rains and evaporation over this portion of country.

So far in the above, I have endeavoured to expose the natural

causes which both produce and regulate the discharges of the River St. Lawrence, and this in the absence of any registered observations of them—or even of the annual variations of this river—which if I were possessed of, might have led to some determinate values or quantities as elements for the solution of this physico mathematical problem. It is fortunate as it is, that we sometimes are enabled from our daily and ordinary observation and experience, to trace the operations of many of the laws of nature, and follow them in their apparently mysterious courses—and if we cannot exactly measure or definitively mark their progress in each step—yet, we often may at least detect as it were nature in her positive tendency or directions—and thence draw conclusions as to her most probable or predominating results.

PETER FLEMING,
Civil Engineer.

DUNDEE, January 7, 1849.